Contamination

EAFB is currently being investigated for potential contamination in all areas of the base. Potential sites for X-33 activities may be included in the investigation. Approximately 200 individual sites have been investigated with no impact to nearby operations or installation restoration program (IRP) activities. IRP field activities are planned in conjunction with nearby base activities so that impacts are avoided. Field activities are scheduled with flexibility built in to allow down time due to contiguous base operations. For example, many locations near the Birk Flight Test Center were investigated, but only when they would not impact the B-2 mission.

None of the sites on WSMR are anticipated to have a soil contamination problem.

Previous activities at SLC-37 on the ER have potentially contaminated soils and groundwater from spills of fuels, solvents and other chemicals. A Pre-Assessment Contamination Study performed in September of 1993 resulted in the identification of two types of contaminants: dichloroethene and vinyl chloride. Maximum contamination was found to be 260 and 27 parts per billion, respectively.

Depending on the site selected during Phase II design, site specific field surveys may have to be conducted at either EAFB or the ER to determine the presence and extent of such soil (and possibly groundwater) contamination. Should contamination be found at a proposed X-33 site, a plan for remediation, avoidance, or baselining of the contamination issues with provisions developed to ensure that no X-33 activity will contribute to migration of the contaminant other than by existing conditions would have to be developed. Because the extent of such contamination is not known at this time, determination of potential impacts to cleanup operations is not possible. However, it appears that such operations would have only minor impact. Because there is no known potential for existing contamination currently at WSMR, it is listed as no impact.

ES/QD

Due to the potentially explosive nature of LH_2 and LOX propellants used by X-33, takeoff site, landing site, and propellant storage facilities have to be sited in accordance with the ES/QD separation requirements of DOD 6055.9 and appropriate USAF, U.S. Army, and NASA regulations.

The EAFB proposed takeoff sites are expected to meet ground ES/QD requirements. Fueling will most likely be from portable tanks located at the takeoff site. The tanks have been included in the siting determination. The munitions storage bunkers midway between Building 730 and the South Base Site will not be a concern because by the time of X-33 flights, use of the bunkers for munitions storage will have been phased out. In summary, there are no anticipated ES/QD related impacts for any of the proposed takeoff sites on EAFB.

Proposed takeoff sites at WSMR are already sited for similar operations. Fueling will be from portable or relocateable ground storage tanks. There should be no ES/QD related impacts at these sites.

The two proposed takeoff sites on the ER have been used for many years with aerospace vehicles using much larger quantities of LH_2/LOX than X-33 will use; therefore, all associated facilities are properly sited. Takeoff from SLC-37 will require fueling from tankers or placement of some fueling infrastructure. Tankers are already available to transport fuel from existing storage tanks on the range. KSC LC-39 has permanent LH_2 and LOX storage tanks in place.

Transportation

LH_2 and LOX will be transported to the selected takeoff site via tanker trucks designed to carry these commodities. These trucks must meet DOT design requirements in order to travel over public roadways. Design requirements are intended to minimize the possibility of a spill, fire, or explosion in the event of a vehicle accident.

All three ranges have established routes for transport of hazardous commodities on-site that are designed to minimize risk to personnel and the transport vehicle. WSMR provides a fire escort with the vehicle. EAFB and the ER do not. Due to its mission of launching the Space Shuttle and large expendable launch vehicles, the ER has extensive experience with transporting large quantities of LH_2/LOX. There have been no major incidents involving transportation of these commodities on the ER. EAFB and WSMR have had limited experience with these commodities but have also not experienced any major transportation incidents. There is no expected impact due to the transportation of LH_2/LOX on the proposed ranges.

Off-site, tankers carrying hazardous materials travel over public roadways. The X-33 Program will result in an increase in the number of shipments to the selected range. Based on stringent design requirements of the vehicles, proven safety record of the companies involved in production and transportation of LH_2/LOX, and relatively small number of additional shipments required, no impacts are anticipated resulting from transportation of hazardous materials over public roadways.

4.2.10 Health and Safety

Flight Safety

The purpose of all three ranges is testing aerospace vehicles and systems. They all have established procedures for testing new vehicles as well as established requirements for worker health and safety. Protection of facilities due to fuel, overpressure, and vehicle failures while on the ground is provided by separation distance. Hazard distances due to quantity of fuels and possible spaceplane failure will be calculated for the selected spaceplane, and no personnel will be allowed inside this distance during takeoff or landing.

Flight paths on-range will be chosen such that there is limited/minimal risk to personnel, either by flying over unpopulated areas or evacuating personnel from affected populated areas. This type of flight path clearing operation is common to all three ranges. Anticipated impacts to health and safety resulting from on-site flights are considered minimal.

Non-Flight Safety

Non-flight hazards to personnel from the X-33 flight test program result from spaceplane assembly and handling operations, fueling operations, and post-landing deservicing operations. Specific hazards encountered will depend on the spaceplane selected. Hazards will be minimized by ensuring that personnel follow detailed operating procedures for spaceplane processing activities and comply with applicable health and safety requirements. Work on all three ranges requires compliance with requirements of OSHA (29 CFR 1900-1999) to protect the health and safety of their workforce. Personnel must also comply with a variety of local and organizational regulations that address health and safety requirements more stringent than OSHA's or that address areas not covered by OSHA. All three ranges have comprehensive health and safety programs run by dedicated health and safety professionals. All personnel involved with the X-33 flight test program will be required to comply with respective range safety programs.

All of the ranges maintain emergency response capability to rapidly respond to fires, medical emergencies, and incidents involving hazardous materials. All three have on-range fire departments and maintain mutual aid agreements with fire departments in surrounding communities. At EAFB and WSMR, medical services are provided by on-range hospitals as well as occupational health clinics. The ER has on-range clinics near both proposed takeoff sites; and EAFB, WSMR, and the ER all have the equipment necessary to transport sick or injured personnel to nearby community hospitals. Health monitoring programs to minimize employee exposure to unacceptable levels of hazardous chemicals, noise, and radiation are ongoing at all three sites.

Because all of the ranges are routinely involved in flight operations of aerospace vehicles, they have adequate programs in place to minimize health and safety risks to workers from these activities. They also have the capability to rapidly and effectively respond to any of the emergency situations that could be expected to arise during the course of the X-33 flight test program. Therefore, no impacts are expected to on-site health and safety.

4.2.11 Land Use

The dry lakebeds at EAFB are primarily for aircraft development flight tests and emergency landing. Primary missions are to conduct and support tests of aircraft systems; conduct flight evaluation and recovery of aerospace research vehicles, and development and testing of aerodynamic decelerators; operate the Air Force Test Pilot School; manage, operate, and maintain the Utah Test and Training Range and the EAFB Flight Test Range; and support and participate in Air Force, DOD, other Governmental agency, foreign, and contractor test and evaluation programs. Rocket engines using a variety of propellants are currently tested at the PL. The base also provides an alternative landing site for NASA's Space Shuttle.

As a national test range, WSMR contains an extensive complex of takeoff sites, impact areas, instrumentation sites, facilities, and equipment. Missile launch sites are located throughout the range. Although numerous missile impact areas have been designated and are specified for missions, almost any non-restricted area of the range can be used for missile impact. The range is the largest overland test range available for the U.S. Army, USN, USAF, NASA, and other agency missile and test flights. WSMR has several operational areas throughout the main range that support various test missions.

Land use at CCAS is planned and managed by requirements to support highly hazardous, large-scale missile test and launch activities. The largest land use zone (57 percent) contains active and inactive launch complexes, ordnance storage, spin test, and other launch-related support facilities. The second largest land use category (31 percent) contains missile assembly and checkout buildings, explosives magazines, and the Range Operations Control Center. Port operations (1 percent) support both commercial and industrial activities, including the NASA Space Shuttle Program, Navy Trident Program, and Navy Fleet Ballistic Missile Program. Airfield operations is another 8 percent of land use; aircraft permitted to use the Skid Strip are those involved in delivery of missile components, aircraft carrying personnel engaged in official Government business, and aircraft used in direct support of missile launches. The remaining 3 percent of CCAS contains assembly and checkout buildings, laboratories, clean rooms, office buildings, and Operations and Checkout (O&M) support shops.

Overall zoning and land management objectives of KSC are to implement and maintain the Nation's space program while supporting alternative land uses in the Nation's best interest. KSC's operational areas are located on approximately 5 percent (2,630 ha (6,507 ac)) of the total land mass (56,450 ha (139,490 ac)). Approximately 62 percent of the operational areas contain LC's 39A and 39B, VAB, SLF, other direct launch and landing support structures, and various administrative, logistical, and industrial support facilities. The remaining undeveloped operational areas are dedicated as safety zones or held in reserve for future expansion.

Since operations to be undertaken by the X-33 Program are currently being performed at the proposed takeoff sites, they are compatible with the missions and capabilities of those sites. Site preparation activities are not expected to affect more than 10 acres, which is far less than 0.5 percent of current operational areas at any one range. All three sites have reserved areas for future expansion. Therefore, the X-33 Program is not expected to impose any changes in or impacts on land use regardless of takeoff site selected.

4.2.12 Operational Noise

Personnel exposure levels in industrial shops and processing facilities at the three proposed takeoff sites are routinely monitored for compliance with standards established by OSHA. The vast airspace available at EAFB and its isolated location in a remote and sparsely populated area greatly mitigate the noise caused by aircraft testing on base. Flight activities at WSMR are at high enough altitude and low enough frequency to generate sound levels anticipated to be no greater than 70 dBA. During Space Shuttle, Delta, and Titan launches at the ER, observer areas and security zones are set at distances where the 115 dBA maximum sound level established for short exposure by the Department of Labor Standards is not exceeded. Therefore only minimal impacts are anticipated.

4.2.13 Transportation

All three ranges have access to major roads and rail lines as well as good internal roadway networks. Roadway capacity is adequate for existing traffic although slowdowns can occur at gates during morning rush hours. The number of people involved in the test program (approximately 100) will have very little effect on road congestion at any of the three largely populated ranges.

Air traffic can be supported at all sites. The primary operational runway at EAFB is the hard surface runway, 04/22, on the Main Base. WSMR will use the main runway at Holloman AFB. Both the Skid Strip on CCAS and SLF on KSC can support large transport aircraft.

Of the four EAFB alternative sites, only the Spaceport 2000 Site 1 would require road improvements. Rail access to all sites would require placement of rail connects to main spurs running on or near the base. The Nike Avenue and WSSH takeoff sites on WSMR have roadway access. ER takeoff sites also have roadway access.

Where roadway access to the takeoff sites is adequate, there will be minimal or no transportation impact. However, if a takeoff site is selected that requires road or rail construction, there may be environmental, cost and schedule impacts. Based on the currently proposed takeoff sites, there will be minor impact at EAFB due to needed, substantial roadway improvements; minimal impact at WSMR due to minimal roadway upgrades; and no impact on the ER due to adequate, existing roadways.

4.2.14 Population and Employment

The X-33 Program is not expected to have substantial impacts on population or employment levels at any of the sites involved. The program will produce only one test spaceplane at an existing aerospace manufacturing plant. The exact location of production facilities will not be known until the Phase II contractor is selected. In addition, a portion of the hardware will be developed at other locations around the country and perhaps outside the United States. This dispersal of work will tend to buffer impacts to any one geographic area. However, regardless of location of the main manufacturing plant, the program will not have the effect of increasing the number of people in the immediate area. In fact, it may have the positive effect of employing individuals who might otherwise be laid off. Given the relatively few number of workers involved (less than 100), impacts would be expected to be minimal.

As for the takeoff site, site preparation activities are expected to employ a relatively small number of people (less than 100) from the local area. The result will be a small, short-term positive economic impact to the economy of the surrounding area. Placement of special test equipment is expected to last 18 months or less. Operations are expected to have an even smaller effect due to the small number of people (less than 50) to be employed for only the duration of the flight test program (approximately 18 months).

For a horizontal landing spaceplane, off-range landing sites will be impacted the least. They will be manned only during test flight operations with a very small contingent of personnel. No construction of new facilities is expected. For the vertical landing spaceplane, placement of the landing pad will require 12 to 18 months and should employ less than 100 workers. Therefore, a small, short-term boost to the economies of these sites would be expected. The scenario for operations, however, would be the same as for the horizontal landers.

Impacts on local economies at the primary flight or secondary landing sites are expected to be minimal.

4.3 Generic Alternatives - Potentially Major Issues

Specific locations of secondary landing site(s) and test flight corridors between primary operations and secondary landing site(s) cannot be evaluated in this EA as noted in Table 4.1-1, preliminary analyses of noise and safety (risk) were performed using (1) Industry Partner supplied data or (2) "reference" spaceplane specifications (see Appendix C) where specifications were incomplete. Results of preliminary analyses are provided in order to ensure that relevant and potentially major environmental issues are recognized and appreciated early in the program. The Federal Noise Control Act directs federal agencies to carry out programs to avoid noise exposures that jeopardize human health or welfare. Preliminary analyses and impact approximations are intended to provide a perspective of these issues to potentially affected regions and enhance the subsequent NEPA analysis. More detailed, refined noise and safety (risk) projections on specific secondary landing site(s) and test flight corridors will be provided in EA-II and used by NASA and the Phase II Industry Partner for determination of final flight test corridors.

4.3.1 Flight Noise and Sonic Booms

Noise is generally defined as unwanted sound. Whether that sound is interpreted as pleasant (music, for example) or unpleasant depends largely on the listener's current activity, experience, and attitude toward the source of that sound. As an example, during a NASA Orbiter reentry event, some groups of individuals will go outside to observe the Orbiter and look forward to hearing its resultant sonic boom. Hence, the attitude of the listener as well as the intensity and frequency of the sound determines the degree of annoyance.

Noise generated by the X-33 spaceplane was analyzed for four distinct flight phases:

- takeoff
- ascent (moving rocket)
- supersonic flight
- landing (vertical landing only)

Impacts of noise on human/animal populations and buildings/structures are described separately.

Noise is measured and described in several ways. Table 4.3-1 provides units and definitions of noise terminology and measurements that will be used in following discussions.

For basis of comparisons, maximum A-weighted sound levels for typical events are shown in Figure 4.3-1. Details of noise impacts and threshold levels and ranges are provided in the following sections to enhance understanding of the preliminary X-33 noise projections summarized in this EA.

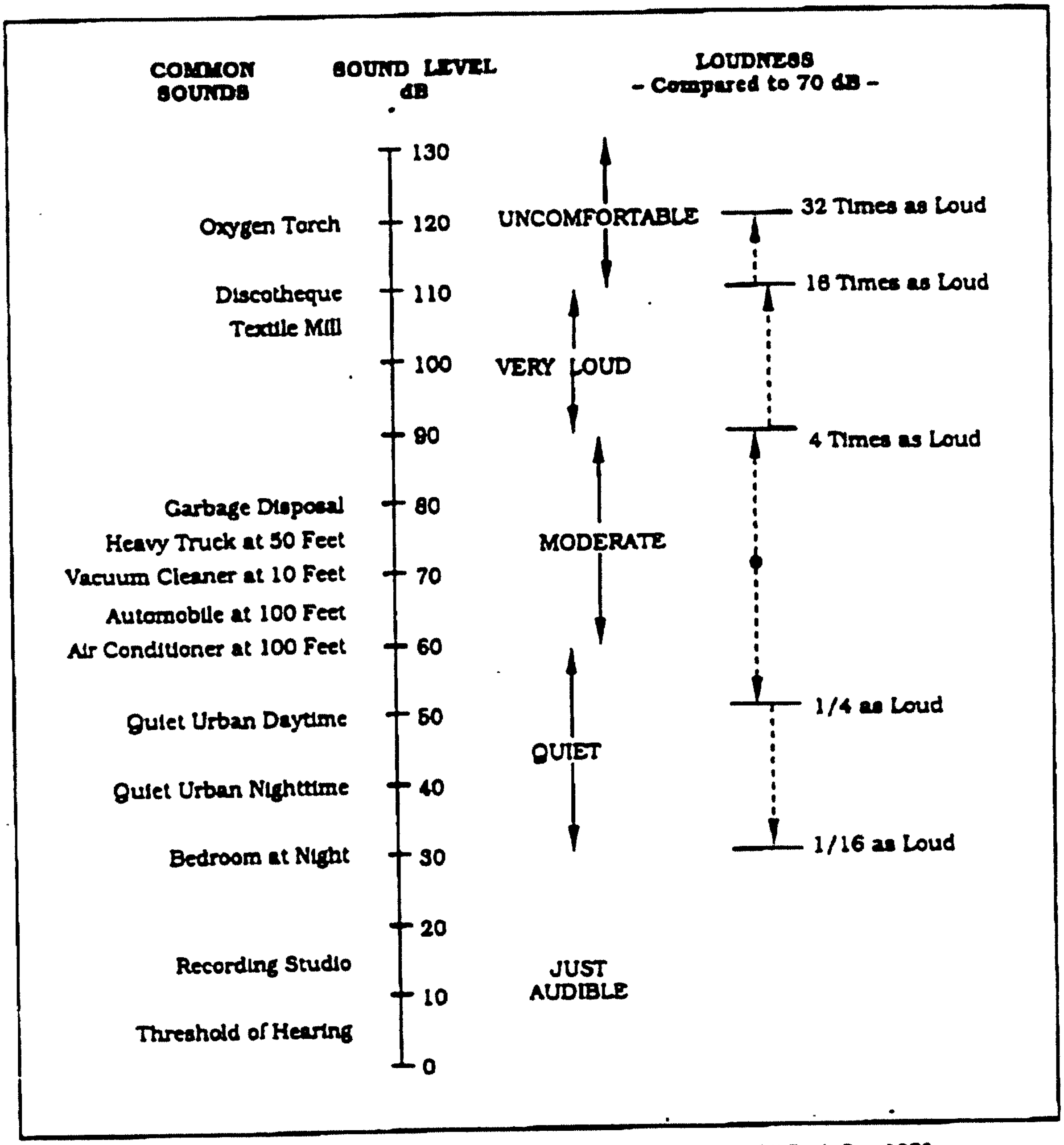
Table 4.3-1. Noise Level Units and Definitions or Explanations

Abbreviation/Unit	Term	Definition
dB $dB = 20 * \log_{10}(\overline{p'} / p_o)$ $p_o = 20 \mu N / m^2$ N - Newton, m - meter, p - pressure	decibel	Accepted standard unit of measurement of sound amplitude or "loudness" logarithmic unit.
dBA	A-weighted sound level	Adjusted sound level to the human ear's lower sensitivity to certain frequencies.
dBC	C-weighted sound level	Adjusted sound level to limit the low and high frequency portion of the sound.
cps or Hz	cycles per second or Hertz	Number of times per second air vibrates or oscillates as sound travels through it; also referred to as sound frequency. The human ear normally detects sound frequencies of 20-15,000 Hz.
OASPL	Overall Sound Pressure Level	Total sound pressure level using all frequencies.
L_{dn}	Day-Night average sound level	The 24-hour energy average A-weighted sound level with a 10 dB weighting added to those levels occurring between 10 p.m. and 7 a.m. the following morning.
psf (N/m^2 or Pa) (also expressed as dBC)	Peak Overpressure	Maximum pressure which the sonic boom produces above existing atmospheric pressure.

Community Noise and Annoyance

For the basis of evaluating the effect of noise on a community, another noise measurement used is the Day-Night Average Sound Level (L_{dn}). Time-average sound levels are measurements of sound levels that are averaged over a specified length of time. These levels quantify the average sound energy during the measurement period. L_{dn} averages sound levels at a location over a 24-hour period, with a 10 dB adjustment added to noise events that occur between 10 p.m. and 7 a.m. local time. The 10 dB "penalty" represents the added intrusiveness of sounds that occur during normal sleeping hours because of increased sensitivity to noise during those hours and typically 10 dB lower sound levels during nighttime than daytime hours. L_{dn} does not represent the sound level heard at any particular time, but represents the total sound exposure. Scientific studies and social surveys of community annoyance to all types of environmental noise found the L_{dn} to be the best measure of annoyance. Its use is endorsed by the scientific community. (ANSI 1980, ASA 1988, EPA 1974, FIC 1980, and FIC 1992)

Results by Schultz (1978) show good consistency in the attitudinal surveys conducted in different countries to find the percentages of groups of people who express various degrees of annoyance when exposed to different levels of L_{dn} (see Figure 4.3-2). In general there is a correlation coefficient of 0.85 to 0.95 between the percentages of groups of people highly annoyed and level of average noise exposure. (NOTE: A correlation coefficient of 1.0 represents 100% consistency.)



Source: *Handbook of Noise Control*, C.M. Harris, Editor, McGraw-Hill Book Co., 1979

Figure 4.3-1. Typical A-Weighted Sound Levels of Common Sounds

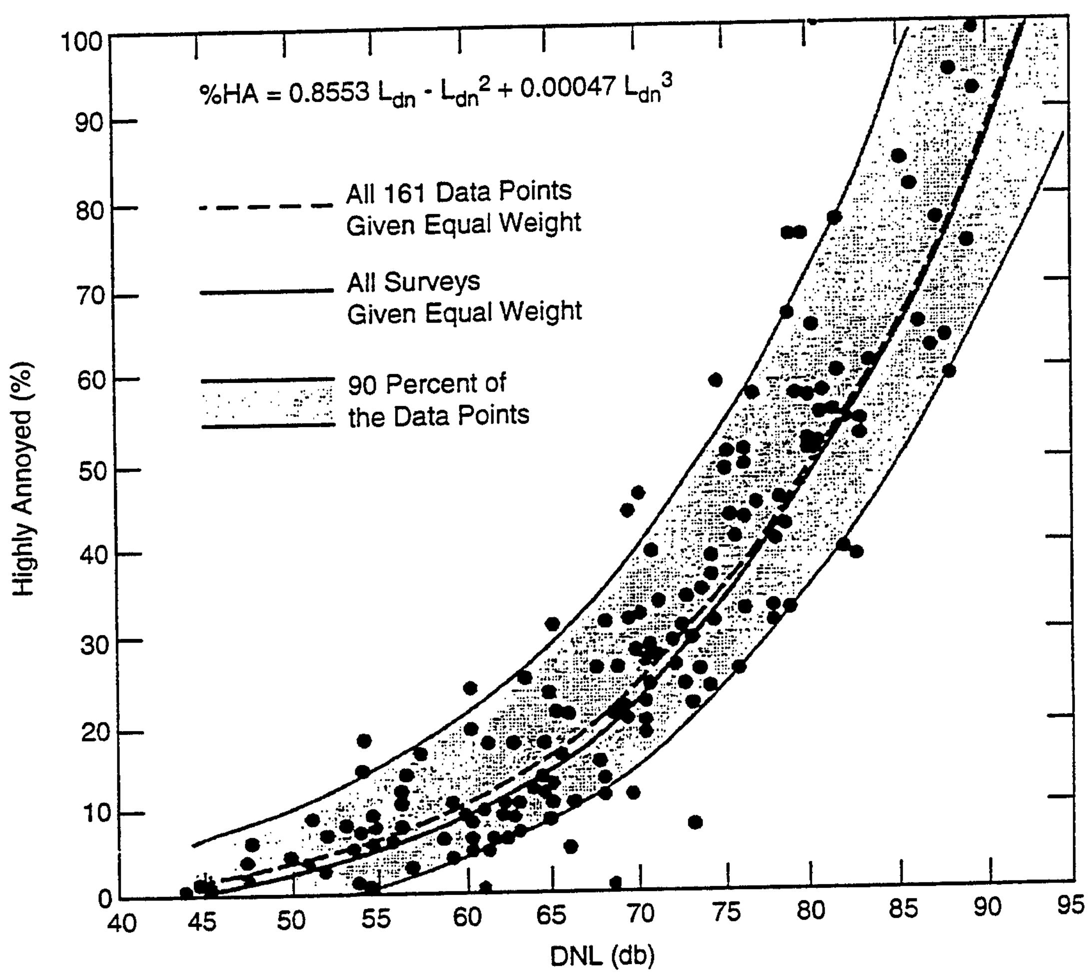


Figure 4.3-2. Community Surveys of Noise Annoyance

However, the correlation coefficient for the annoyance of individuals is relatively low, 0.5 or less, which is not surprising considering the varying personal factors that influence the way individuals react to noise.

Noise Effects on Structures

Damage to buildings and structures from noise is generally caused by low frequency sounds. To better estimate the impact of noise on a structure, a C-weighting is used. A and C weightings are compared in Figure 4.3-3. The probability of structural damage claims has been found to be proportional to the intensity of the low frequency sound. One claim in 10,000 households is expected at a level of 103 dB, one in 1,000 households at 111 dB, and one in 100 households at 119 dB (see Figure 4.3-4).

Speech Interference

Speech interference can occur at ambient noise levels above 60-70 dBA. This effect means that people engaged in conversation outdoors would have to speak louder or move closer together to continue the conversation. In some locations, the level will be above 70 dBA during tests or flight, and conservation will be momentarily interrupted. However, tests and flight noise will be of short duration, 2 to 3 minutes, and infrequent, and therefore, the impact of the disruption would be minimal.

Sleep Interference

Interference with sleep can occur at levels as low as 45 dBA. Since most people sleep at night, daytime testing activities would not interfere. People who sleep during the day must normally learn to sleep with a greater level of exterior noise. However, at levels approaching 95 dBA, some interference to daytime sleepers would be expected. Because of the infrequency of tests, the short duration, and small number of daytime sleepers, impact would be small at any site.

Sonic Booms

A sonic boom is a very short term, impulsive event. Therefore, the above noise criteria are not a good measure of its effects. There are several units used to express sonic booms. For this report, peak overpressure levels will be expressed in pounds per square foot (psf). The effect of sonic booms on humans is different than the effect of a "steady state" rocket noise. Sonic boom annoyance is better described as a startling event. Sound levels are similar to thunder from nearby lightning strikes, but can occur on a clear day. During a storm, lightning and thunder cannot be predicted to occur at a specific place or time, but they are commonplace. Therefore, some of the annoyance of sonic booms is due to their uncommon, unpredicted occurrence. Figure 4.3-5 shows a summary of survey data on the acceptance of sonic booms versus peak overpressure levels. A sonic boom of 1 psf would be accepted by 95% of the population, and a 0.4 psf sonic boom would be accepted by 99% of the population.

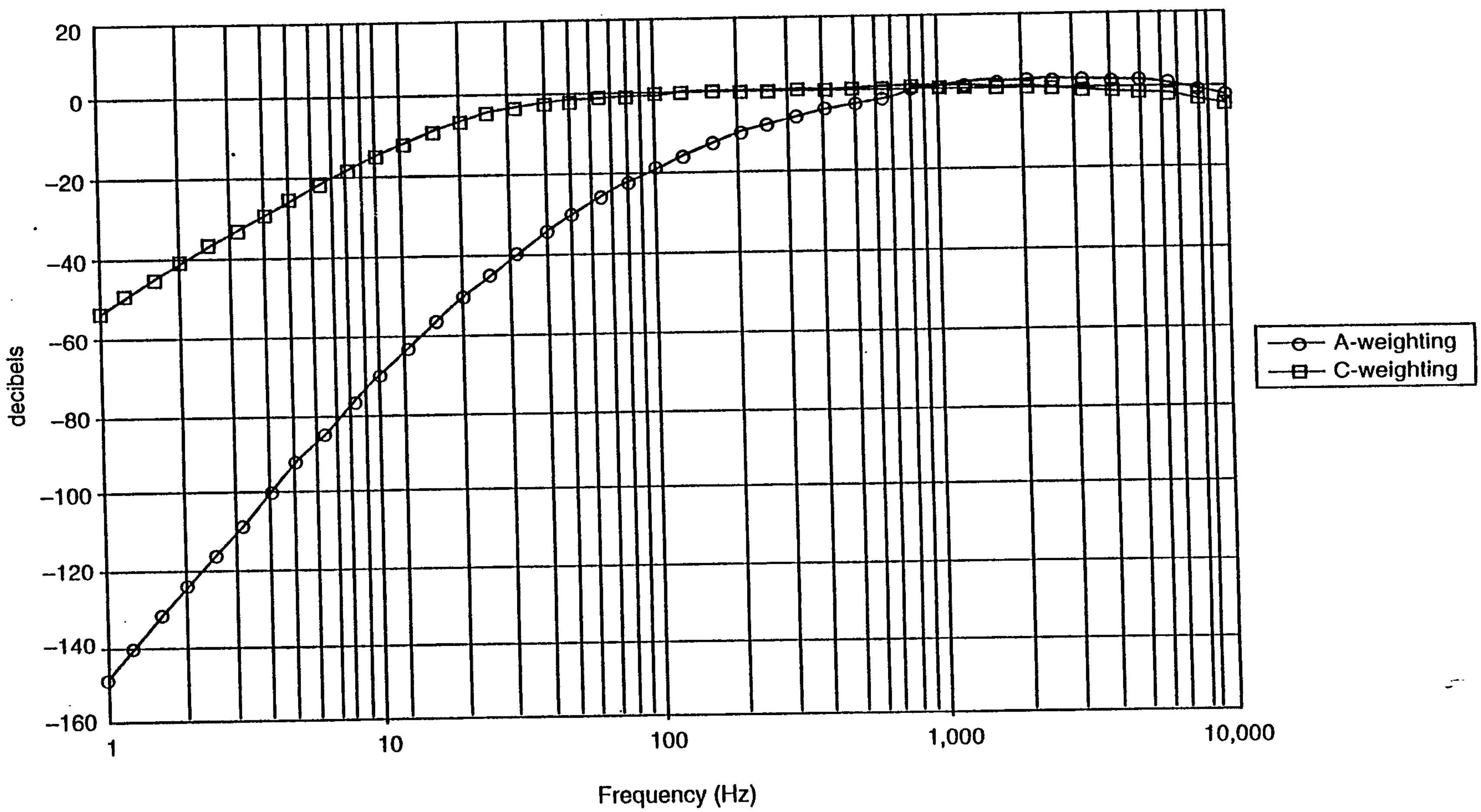


Figure 4.3-3. Comparison of A and C Weighting Curves

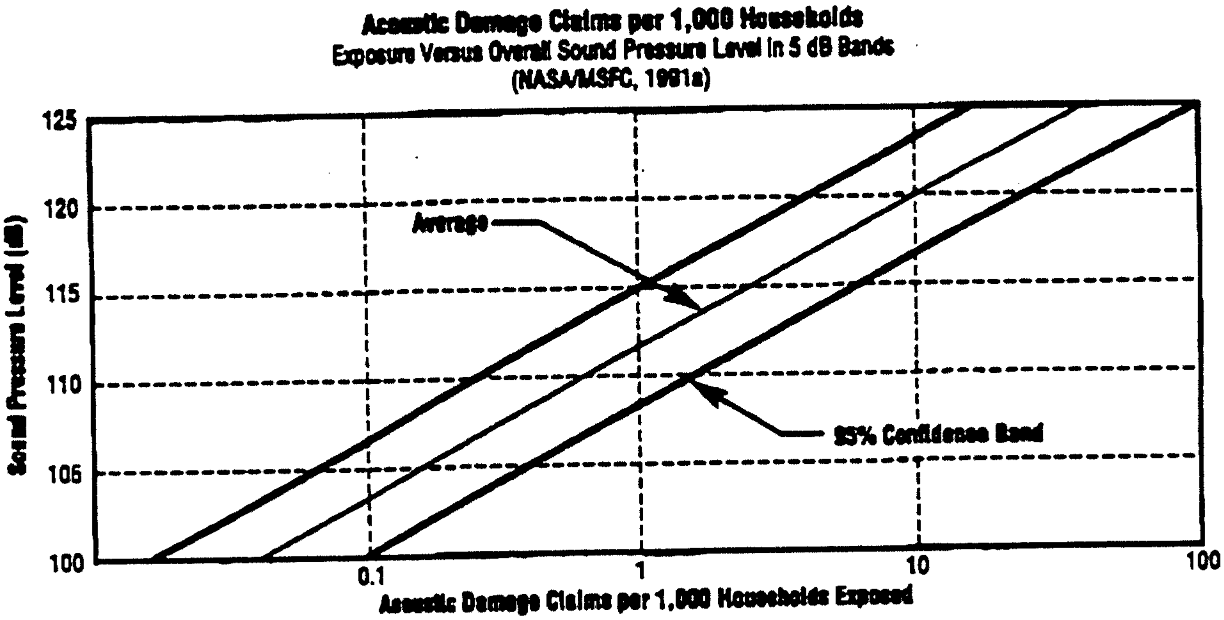


Figure 4.3-4. Structural Damage Claims versus OASPL

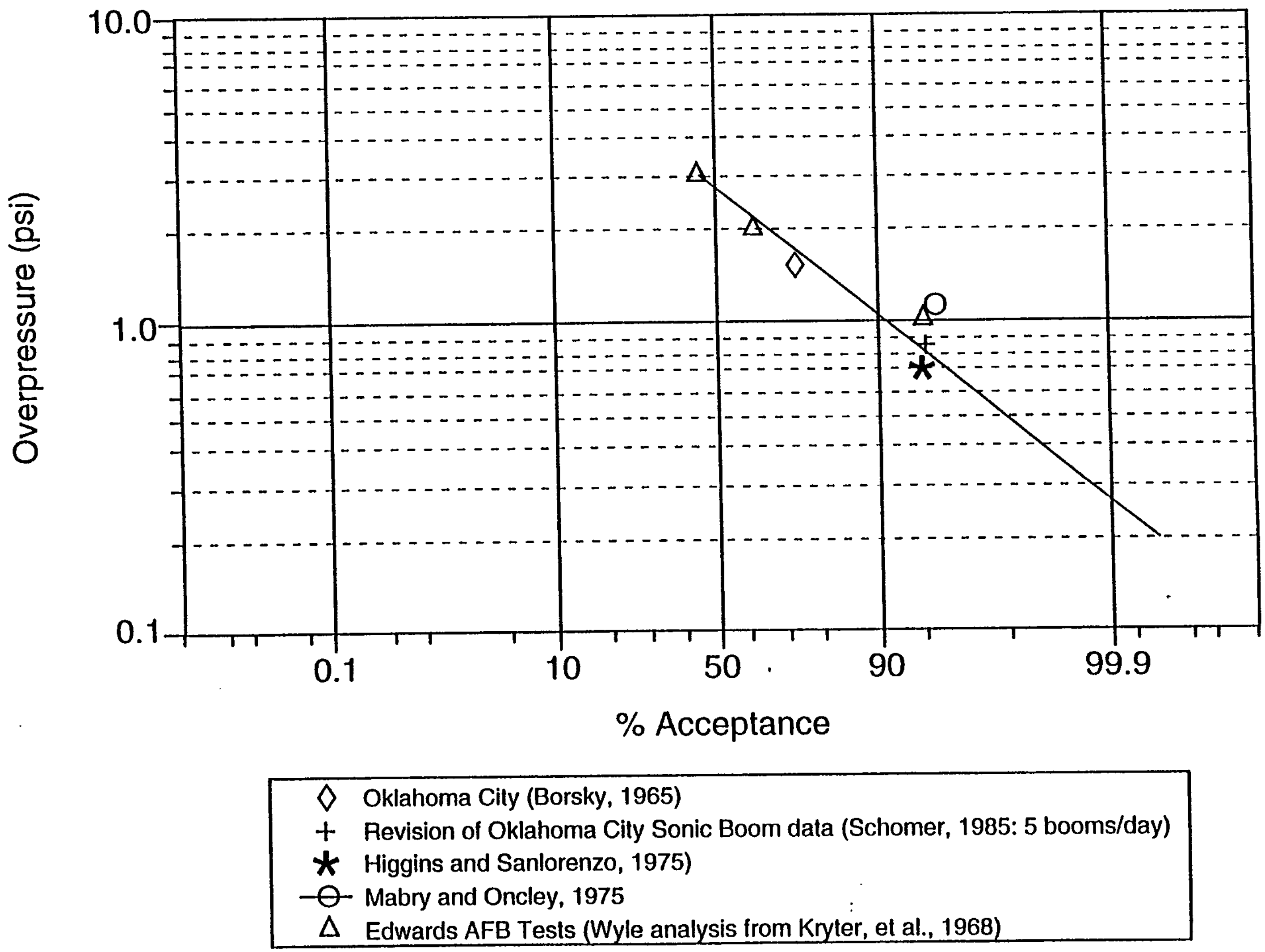


Figure 4.3-5. Summary of Sonic Boom Acceptance Data

Acoustic Focusing

Another important factor that determines the acoustic environment is acoustic focusing due to certain atmospheric conditions. This effect is related to the refraction or "reflection" of the acoustic energy as it propagates (moves) through the atmosphere. Refraction occurs when meteorological conditions of temperature and winds are such that the speed of sound increases with increasing altitude. This condition refracts the sound energy, resulting in higher levels at a given point than those which would be expected otherwise. Generally, for liftoff/static test conditions, the speed of sound profile characteristics of only the lower atmosphere (altitudes less than 5,000 to 10,000 m (16,000 to 32,000 ft)) are effective in returning sound energy to the ground. Experience shows that sound pressure levels in the far field can increase in some areas on the order of 20 dB due to atmospheric refraction effects. Acoustic focusing is not modeled in the takeoff/static test, landing, and moving rocket noise predictions in this report. The effect of refraction and how it will be predicted and mitigated will be addressed in EA-II.

Takeoff Noise

To estimate takeoff noise environments, conservative values of thrust, nozzle exit gas velocity, and nozzle exit diameter were used. This analysis assumed a takeoff pad geometry similar to Saturn or Shuttle (i.e., 45 degrees deflected exhaust). Takeoff and static test noise environments were estimated using methodology defined by the Chemical Propulsion Information Agency (CPIA 1971). The model assumes no acoustic focusing. These environments will be updated in EA-II.

Preliminary liftoff noise levels will be at or below 110 dB approximately 6 km (3.7 mi) from the takeoff site. Workers will noticeably hear takeoff at distances exceeding 10 km (6.2 mi). The above distances are within each of the ranges, and preliminary takeoff noise projections indicate that off-site receptors should not be bothered by this phase of the noise profile from takeoff.

Moving Rocket Noise

Although the moving rocket noise generation process is the same as the takeoff/static test case, the noise environment of an ascending rocket is predicted using a different model. The main differences are a deflected exhaust for takeoff/static test condition and effects of an accelerating rocket moving away from a listener for the moving rocket case. Moving rocket noise levels are a function of thrust, nozzle exit gas velocity, nozzle exit diameter, altitude, downrange distance, flight path angle, and ground track direction. Noise emission characteristics (total sound power, spectrum, and directivity) are taken from the method of Sutherland (1993) and NASA (MSFC 1963). Effects of acoustic focusing were not modeled.

The rocket engine parameters used were the same as the takeoff/static test conditions. Preliminary results for moving rocket noise are based on a trajectory considered to be typical for an X-33 ascent in terms of cross range distances and climb rate. Maximum projected dB, dBA, and dBC sound levels are at or below 100, 60, and 100, respectively, offrange. These sound levels should not annoy or damage property off the ranges. The L_{dn} and LC_{dn} values of 40 or less dB are within range boundaries. Noise projections will be refined and detailed in EA-II.

Landing Noise Environment

One of the X-33 spaceplane designs uses rocket engine thrust to decelerate and land vertically. The landing noise environment was estimated by slightly modifying the takeoff/static test noise prediction code. The main differences between takeoff and landing conditions are reduced thrust and a simple flat plate deflector used for landing. Approximately 105-110 dB overall sound pressure level (OASPL) and 100-105 dBA noise levels at touchdown would be generated within 2.5 km (1.6 mi) of the landing site. Moving rocket noise modeling on descent has not been performed and will be included in EA-II.

Sonic Boom

A typical X-33 spaceplane will fly supersonic velocities over long distances (i.e., over 500 miles). Therefore, areas overflown will experience the pressure wave generated by the spaceplane, generally referred to as a sonic boom. It is beyond the scope of this document to describe sonic boom phenomena or methodologies used to predict the event; however, a good review of sonic boom theory is presented by Plotkin (1989). In general, the amplitude, duration, and location of a sonic boom are a function of the spaceplane shock signature (shape), trajectory, and atmospheric conditions. Shock signatures for X-33 spaceplanes are similar to each other and to those of the Shuttle Orbiter. Rocket engine plumes were not modeled during the ascent phase of the flight. Plume effects will be addressed in EA-II.

Spaceplane shock signatures were developed by Plotkin (1996). Trajectories for each spaceplane were supplied by the respective Industry Partner. Atmospheric effects of temperature and winds were addressed in these predictions. EAFB annual average atmospheric temperature and wind profile were used for sonic boom footprint predictions.

Preliminary sound modeling of sonic booms produced after takeoff and focusing on a narrow region of property indicate that sound pressures of approximately 3.2 psf (see Table 4.3-2 for typical sonic boom dBC equivalents) would be experienced at distances of approximately 100 km (60 mi) from the takeoff site. Table 4.3-3 provides possible structural damages versus sonic boom sound pressures. Sonic booms with sound pressures in the range of 2-4 psf could produce damage to glass, plaster, roofs, and ceilings. Due to the nature of the X-33 Program objectives, the selected range, and trajectory(ies), sonic booms may not be confined to the test range. Careful management of the flight trajectory can minimize exposure of sonic booms on communities.

Table 4.3-2. Typical Sonic Boom Overpressure Ranges and Equivalents

Overpressure (psf)	dBC	Common Equivalent
0.5 - 2	121 - 133	Pile driver at construction site.
2 - 4	133 - 139	Cap gun or firecracker near ear.
4 - 10	139 - 147	Handgun as heard at shooter's ear.
10 - 14	147 - 150	Fireworks display from viewing stand.